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Original Research Article

Climate Change Perceptions, Impacts and Adaptation by Smallholder Farmers. A Household Survey in Western Kenya

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Abstract

The purpose of this study is to explore the climate change perceptions and its impacts on the livelihoods of smallholder farmers at household level in western Kenya with particular reference to Homabay County. Kenya, like most other developing countries has experienced extreme climate events including droughts and floods with ensuing socioeconomic consequences. Historic analysis of weather in Homabay County shows that both dry spells and extreme precipitation are hazards in the County.The study employed cross-sectional survey design in which data was collected from smallholder farmers in one survey round. Data was analysed using frequencies, percentages and trend analyses of climatic patterns. The study established that most smallholder farmers had experienced changing climatic conditions. The major changes ranked in order of importance during focus group discussions included prolonged dry spells, heavy but occasional rainfalls, drying water points, diminishing grazing areas and diminishing indigenous tree species. Given the over reliance of smallholder households on rain-fed agricultural activities for their livelihoods, they are very vulnerable to adverse weather conditions. The effects of climate change in the study area were in the form of crop failure, famine, livestock disease outbreak, human disease outbreak and disruption of settlements. The study recommends the need to entrench agricultural systems that build resilience to climate change and reduce green-house gas emissions from farming activities. There is also need to have reliable and accessible weather information to enhance farmers' mitigation preparedness in curbing climate change impact. The link between the department of agriculture and meteorological department should be strengthened for easy dissemination of weather information. There is need for establishment of meteorological stations at levels that can be accessed by the farmers, including community resource centres and schools and community resource persons and teachers empowered to disseminate climate information to the farmers.

Keywords: Climate change impacts, Climate change perception, Homabay County, Kenya, Smallholder farmers

INTRODUCTION

Climate change is recognized as a most serious threat facing humanity and will affect different ecosystems and sectors over the coming decades, with specific impacts on agro-ecosystems (IPCC, 2007). The impacts will include decreasing plant and animal species diversity, shifts in ecosystems composition, reduction in quality and

quantity of irrigation water, increasing aridity and desertification and increasing incidence and impacts of crop pests and diseases (IPCC, 2007).

Economists have warned that the economies of developing countries will be adversely affected by climate variability and change due to their overdependence on natural resources and rain-fed agriculture (Pearce, 1996; Tol, 2002; Mendelsohn et al., 2006). For example, biomass provides about 80% of the primary domestic energy supply in Africa, while rain-fed agriculture contributes some 30% of GDP and employs about 70% of the population, and is the main safety net of the rural poor (World Bank, 2012). In addition, Africa's vulnerability is exacerbated by the fact that Africa is home to the largest number the world's poor, with extreme poverty index as high as 48% (AfDB, 2011).

Kenya has experienced extreme climate events including droughts and floods with ensuing socio-economic consequences. The country continue to experience recurrent droughts such as in the years 1983/1984, 1991/1992, 1995/1996, 1998/2000, 2004/ 2005, and 2008/2011, each of which caused severe crop and livestock losses, famine and population displacement (RoK, 2016). In the 1997-2016 period, the country experienced an average of 57.95 deaths per year and GDP losses of 0.362% per year due to extreme weather events (Eckstein et al., 2016).

Climate change introduces additional uncertainty into existing vulnerabilities, particularly in the arid and semi-arid lands which cover 80% of the country (RoK, 2012). The 2008/2011 drought led to some of the devastating and pervasive socio-economic consequences (RoK, 2016). The drought is estimated to have slowed down the GDP by an average of 2.8 percent per annum, with total loss estimated at USD 12.1 billion (RoK, 2012). The most affected sector was livestock suffering a loss of USD 87.43 billion followed by crop production with a loss of USD 1.51 billion (RoK, 2012). The 2014-2018 droughts were declared a national emergency in 2017 in which 23 out of 47 counties were affected. This led to food insecurity for about 3.4 million Kenyans and an estimated 500,000 could not access clean water (RoK, 2018).

Floods have also caused devastating effects to socio-economic activities in Kenya. The economic costs of flooding to the country are very high, resulting to losses of about 5.5% of GDP every seven years (RoK, 2012). Flood-related fatalities in the country constitute 60% of disaster victims (Otiende, 2009). The floods in early 2018 claimed over 183 lives, displaced more than 225,000 people including 145,000 children, and closed over 700 schools (KMD, 2018). The floods led to cholera outbreaks in at least five counties and people experienced an upsurge of mosquito-borne diseases such as malaria and dengue fever (KMD, 2018). Between 1990 and 2015, a total of 43 flood disasters were recorded in Kenya, which is equivalent to an average of 1.65 flood disaster per year, with each flood disaster affecting 68,000 people (Emergency Events Database, 2015).

The greatest challenge facing Kenya today is how to reduce poverty and achieve sustained economic growth for national development. Agriculture in Kenya is the engine for this economic growth and will remain so in the foreseeable future (RoK, 2012). The country's economy is highly dependent on climate sensitive sectors including agriculture, tourism, and energy (Mutai et al., 2011). While Kenya already experiences an increase in rainfall variability, 75% of the agricultural output remains dependent on rain-fed small-scale agriculture (Herrero et al., 2010).

The situation is not different in Homabay County. Historic analysis of weather in Homabay County shows that both dry spells and extreme precipitation are hazards in the County (RoK, 2016).Farmers in Homabay County attest to the on-going and intensifying changes to climate and weather patterns in the County over time. Increased cases of flooding have been reported around Magunga in Gwasi, Sindo areas, Wahambla in Homabay, lower parts of Ndhiwa, Lambwe area and Rusinga in Mbita, lower parts of Kochia and wang'chieng ward in Rachuonyo North sub-county (RoK, 2016). Unpredictable seasonal patterns affecting agricultural activities such as the onset and end date of the seasons have been observed. Uneven distribution of rain coupled with inaccurate weather forecasts lead to more crop failure (RoK, 2016).

Climate change has already had adverse effects on agricultural production systems and food security as a result of increased frequency of extreme weather events and unpredictability of weather patterns (RoK, 2013). Excessive rains and subsequent flooding, shifting patterns of storms and droughts, and warmer overall temperatures are just some of the effects (FAO, 2013). Because crop production in the county is rain-fed and livestock farmers depend mostly on natural pasture, long dry spells and irregular rainfall exacerbate the problem of low yields and leave rural households even more susceptible to food insecurity (RoK, 2016).Therefore, adaptation can greatly reduce vulnerability to climate change by making rural households better able to adjust to climate change and variability, moderate potential damages, and cope with the resulting consequences (IPCC, 2001). This, however, needs a thorough understanding of farmers' perceptions of climate change and climate change adaptation strategies employed at household level.

METHODS AND MATERIALS

The study was carried out in Homabay County. The county is characterised by a rapidly growing population, high population density, falling food production and low resilience to climate change. It is within the Lake Victoria basin which is experiencing erratic weather as a result of

perceived effects of climate change and variability. Most households in the study area rely on primary production for their livelihoods, which include rain-fed smallholder farming and fisheries, practices that are highly vulnerable to environmental degradation and effects of climate change. Poverty is prevalent in the county with about 48% of the population living below poverty line (KNBS and UNICEF, 2013). This is slightly higher than the national average of about 45%. Addressing population growth, environmental degradation, and climate change together should be a top priority if Homabay County is to achieve sustainable development. The county has varied agro-ecological zones giving rise to different land uses. These zones include Upper Midlands 1 (UM1), Upper Midland 3 (UM3), Upper Midlands 4 (UM4), Lower midlands 2 (LM 2), Lower Midlands 3 (LM3), Lower Midlands 4 (LM 4) and Lower Midlands 5 (LM 5). This is representative of Kenya's agro-ecological zones, making Homabay County suitable for the study.

Homabay county lies between latitude 0º 15' South and 0º 52' South, and between longitudes 34º East and 35º East. The study employed cross-sectional survey design to collect information from the respondents according the study objectives. This design was appropriate for this study because the study involved description of the characteristics of the smallholder farmers as they relate to their ability to adapt to the effects of climate change. A sample of 398 smallholder farmers was randomly selected to provide information for the study. Data was analysed using frequencies, percentages, and trend analyses of climatic patterns.

RESULTS AND DISCUSSION

Climate change experience and perception

About 69% of the farmers interviewed reported that they had experienced changes in weather patterns for ten years, while 22.88% had experienced climate changes for 11 to 15 years (Table 1). Experience of climate change occurrence is associated with the number of years that the farmer had spent in farming and hence accumulated local knowledge in adapting to climate change. This means that farmers who had spent more years in farming had accumulated more local knowledge and should be able to adapt to climate change than those who had spent few years farming. The number of years of experience in farming is highly correlated with the level of knowledge and skill related to adapting to climate change and climate variability (Defiesta and Rapera, 2014).

They indicated that climate change had manifested itself in the form of floods (30.72%), drought (43.46%) and alternating drought and floods (23.86%), giving a total of 98.04%. 1.96% of the respondents did not know how climate change manifested itself (Table 1). This gave the climate change markers based on adverse weather changes. There was general perception that temperatures had increased and rainfall patterns had changed. This corroborates with the measured climate variables for Homabay County. Given that most households heavily depend on rain-fed crop farming and livestock production for their livelihoods, they are very vulnerable to adverse weather conditions. The major changes reported and ranked in order of importance during focus group discussions included prolonged dry spells, heavy but occasional rainfalls accompanied by floods, dried water points, diminishing grazing areas, encroachment of human activities into forests, shorter rainy seasons and diminishing indigenous tree species. It was reported during these sessions that these changes were being caused by changes in rainfall patterns, destruction of water catchment areas as a result of human activities, charcoal burning, increase in human population, poor farming practices and air pollution by factories. Reported climatic changes were comparable to other studies conducted elsewhere. Ogalleh et al. (2012) reported that farmers from Laikipia County perceived decreasing rainfall, increasing temperature and less predictable rainfall. Bryan et al. (2009) reported the perception of increasing temperature and decreasing rainfall for Ethiopian farmers. Even though some of the reported changes were not reflected in measured climate data, farmers' perception was determined by incidences during the last 5 – 10 years (Rao et al., 2011). In Homabay County these incidences included a severe drought in 2014 with significant impacts on crop production and rural livelihoods, causing hunger and water shortage.

These perceptions are supported by climate patterns as explained by trends in climatic patterns of Homabay County for the last 10 years.Farmers' perception of climate change was compared with measured temperature and precipitation from Kenya sugar research meteorological station in Homabay County. Although smallholder farmers in sub-Saharan Africa often perceive lack of rainfall as a major cause for decrease in crop production, temperature effects should not be underestimated. Increased temperatures lead to higher evapo-transpiration, which could be mistakenly taken as a decrease in rainfall by farmers (Coe and Stem, 2011; Osbar et al, 2011).

From the analysis, it was observed that the amount of rainfall has been declining over the years from 2009 to 2018 with the highest rainfall being experienced during the years of 2009-2010 while the least amount of rainfall experienced during the year of 2014. The year 2014 also represents the year when the county recorded the highest average temperature during the long rains. This could impact negatively on crop production given that most of the smallholder farmers depend on precipitation for their agricultural production. In order to improve on agricultural production, smallholder farmers will need to invest on climate change adaptation strategies such as

Table 1. Climate change experience in years

Climate change experience in years	Frequency	Percent
5-10 years	211	68.95
11-15 years	70	22.88
16-20 years	12	3.92
more than 20 years	13	4.25

***Source*:** Field survey, 2018

irrigation and planting of early maturing and drought tolerant crop varieties among others to escape the effects of drought. The results are presented in Figure 1.

From the analysis of the average temperature, it can be observed that there is significant increase in the temperature levels from 2009 to 2018 (Figure 2). But the highest temperature was in 2014 and the least in 2010. This increase in temperature coupled with unreliable rainfall results in reduced crop yields. The analysis indicates a significant change in temperature which is one of the climate variables and this may impact negatively on crop production in the study area. The trend analysis of temperature confirms the perception of increasing temperatures by smallholder farmers in the study area. These results are consistent with the study by Solh and Saxena (2011) and IPCC climate predictions for Southern Africa (IPCC, 2007). Maddison (2006) obtained similar results which showed that a significant proportion of farmers in Africa are noticing increasing temperatures. Correct perception of a problem and awareness of the potential benefits of redressing the problem is a critical determinant of climate change adaptation (Nhemachena and Hassan, 2007; Bryan et al., 2009). However, low agricultural productivity could also be as a result of other factors such as declining soil how climate change manifested itself (Table 2). This gave the climate change markers based on disastrous weather changes. There was general perception that temperatures had increased and rainfall patterns had changed. This is in consonance with the measured climate variables for Homabay County. Given that most households heavily depend on rain-fed crop farming and livestock production for their livelihoods, they are very vulnerable to adverse weather conditions. The major changes reported and ranked in order of importance during focus group discussions included prolonged dry spells, heavy but occasional rainfalls accompanied by floods, dried water points, diminishing grazing areas, encroachment of human activities into forests, shorter rainy seasons and diminishing indigenous tree species. It was reported during these sessions that these changes were being caused by changes in rainfall patterns, destruction of water catchment areas as a result of human activities, charcoal burning, increase in human population, poor farming practices and air pollution by factories. Reported climatic changes were comparable to other studies conducted elsewhere. Research has reported that farmers from Laikipia County perceived decreasing rainfall, increasing temperature and less predictable rainfall (Ogalleh et al., 2012). In another study, the perception of increasing temperature and decreasing rainfall was reported among Ethiopian farmers (Bryan et al., 2009). Even though some of the reported changes were not reflected in measured climate data, farmers' perception was determined by incidences during the last 5 – 10 years (Rao et al., 2011). In Homabay County these incidences included a severe drought in 2014 with significant impacts on crop production and rural livelihoods, causing hunger and water shortage.

Impact of climate change in the study area

The livelihoods of most households in the study area like any other place in the Sub-Saharan Africa heavily rely on rain-fed agricultural systems and therefore any change in temperature and rainfall patterns is bound to affect the economies of these households. The results of the study indicate that most of the households were being affected by climate variability and change. These effects were experienced in the form of crop failure (41.13%), famine (23.79%), livestock disease outbreak (17.34%) and human disease outbreak (12.5%). 5.24% of the respondents reported that climate change had led to disruption of settlements. This implies that impact of climate change is enormous and is likely to increase poverty levels in the study area as livelihood systems will be greatly affected. The unreliability of rainfall and the rise in temperatures results in crop failure and ultimately famine occurrence. Climate change has also resulted in creation of new habitats resulting in outbreak of livestock and human diseases. Most of the respondents reported increased cases of malaria in the study area. The rise in temperature provides favourable environment for breeding of disease causing organisms for diseases such as malaria. This is consistent with other studies. Climate change provides suitable conditions for diverse infectious diseases borne by water, air and food (Sonne, et al., 2017).

There were also reported incidences of fall armyworm (*Spodoptera frugiperda*) attack on maize crop which was more intensive during dry weather. There were also reported cases of water-borne diseases such as cholera especially during rainy season coming after drought. Heavy rainfall events transport disease causing

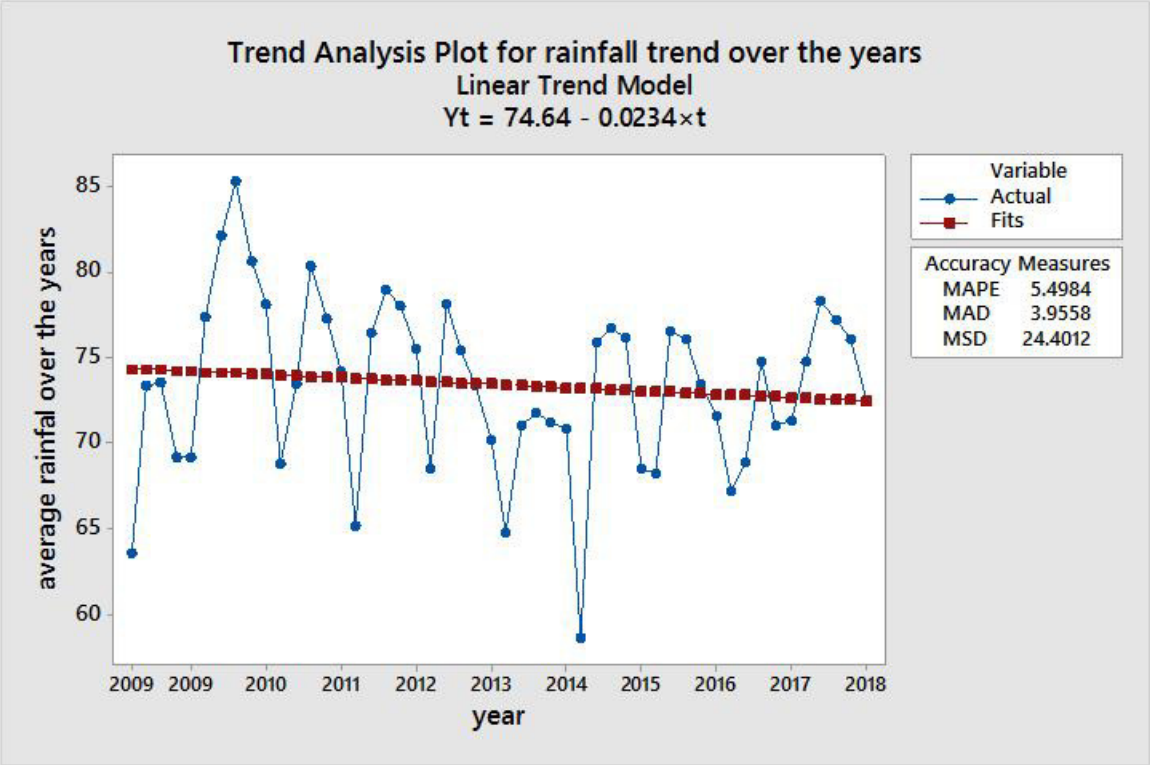

Figure 1. Average Rainfall trend in Homabay County
Source: Kenya Sugar Research Meteorological Data (2009-2018)

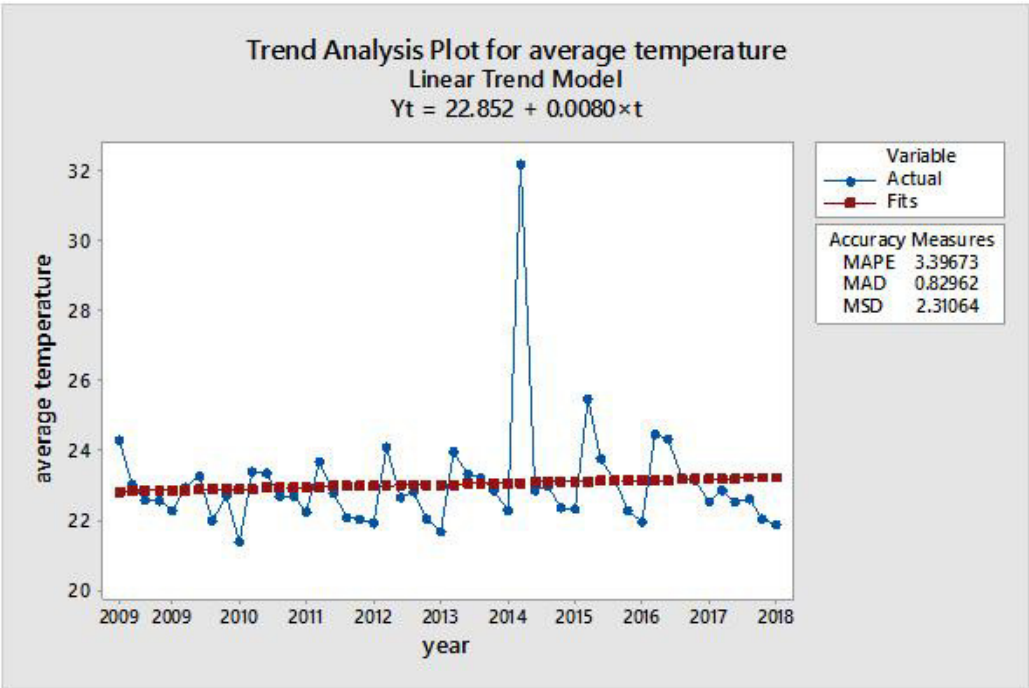

Figure 2. Average temperature trends in Homabay County
Source: Kenya Sugar Research Meteorological Data (2009-2018)

Table 2. Form in which climate change is manifested

Climate Change Manifestation	Frequency	Percent
Floods	134	33.67
Drought	173	43.47
Alternating drought and floods	83	20.85
Don't know	8	2.01

***Source*:** Field survey data, 2018

organisms into drinking water sources resulting in outbreaks of water-borne infections. The results of the study are shown in Figure 3.

On whether climate change poses risk to individual farmers, 40.2% of the farmers strongly agreed, 32.41% agreed while 12.81% were not very sure whether climate change poses individual risk. This is a further indication that most households were already feeling the brunt of climate change and adaptation will provide them with the necessary resilience to cope with its effects. However, some small percentage of the respondents did not believe that climate change poses individual risk to the farmers. Among these, 3.52% strongly disagreed while 2.76% disagreed. 8.29% of the respondents did not know if climate change poses individual risk. The results are shown in Figure 4.

Impact of climate change on crop production

The major factors resulting in low crop yields are drought (26.7%) and floods (16.26%). Drought is a major factor here because most farmers depend on rainfall for their production and therefore with dwindling rainfall patterns, most households will continue to stare at the risk of food insecurity. During floods, water is not a limiting factor but destroys crops by sweeping them away. Emergence of crop pest and diseases was reported by 5.58% of the respondents. The major emerging crop pest and disease reported which were not there before are the fall army worm and maize necrosis disease respectively. Increased pests and crop diseases leading to crop failures and reduced crop production are common in countries and areas where arable farming is predominant (Yesuf *et al.,* 2008; Akponikpe *et al.,* 2010; Nzeadibe *et al*., 2011; Gandure *et al*., 2013).Lack of knowledge of application of new farming methods was also reported as cause for low crop yields. Many farmers were still planting local seed varieties without the use of fertilizers. However, 1.7% of the respondents reported high crop yields due to the use of local seed varieties that were resistant to drought and crop pests. The results are shown in Table 3.

Impact of climate change on livestock production

Livestock farmers reported that climate change and climate variability have led to decreased livestock weight due to lack of enough pastures and water and an increase in livestock death due to livestock disease. Draught oxen that are emaciated and in poor body condition cannot provide adequate draught power for ploughing, and thus affects crop cultivation (Tiruneh and Tegene, 2018). 56.78% of the farmers indicated that there was decrease in livestock production due lack of enough pastures while 29.4% reported that there was a decrease in livestock production due emergence of livestock diseases and parasites. The farmers reported that prolonged drought was the major cause of lack of pasture. Drought severely harms the ecosystem and worsens considerably human crisis (Tiruneh and Tegene, 2018). Quality of forage may be affected by increased temperatures and dry conditions. Temperature increases may increase lignin and cell wall componentsin plants (Polley et al., 2013; Sanz-Saez et al., 2012), which reduce digestibility and degradation rates (IFAD,2010; Polley et al., 2013), leading to a decrease in nutrient availability for livestock (Thornton et al., 2009). There was a general perception among the respondents that grasslands were diminishing and this could be observed through reduced grazing land at household and community levels. The loss of grazing land could be also as a result of clearing of land for crop farming. Conflict over grazing land among community members had become common forcing some community members to move and look for pastures along rivers and near the lake especially during prolonged drought. The respondents reported that climate change was the major cause of emergence livestock diseases and parasites. Increase in temperatures increase the rate of development of parasites and disease causing organisms that spend part of their life cycles outside the host animals. Flooding that usually follow after prolonged droughts provide suitable environment for water-borne diseases. Climate stress (heat, inadequate food and water) can also lower host immunity (Grace *et al*., 2015). Climate change may bring about substantial shifts in disease distribution, and outbreaks of severe disease could occur in previously unexposed animal populations (possibly with the breakdown of endemic stability) (Thornton *et al*., 2009). It was also observed that some households own large herds of local cattle which apart from having low production, burden these households with the need to look for large grazing lands. These households were observed to be incurring more livestock deaths especially

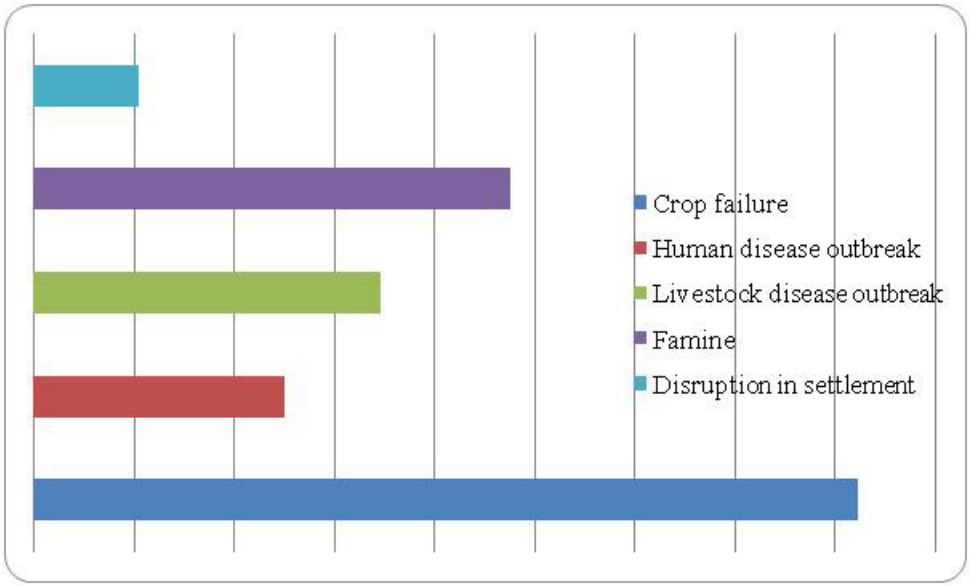

Figure 3. Respondents response on the effects of climate change
***Source*:** Field survey data, 2018

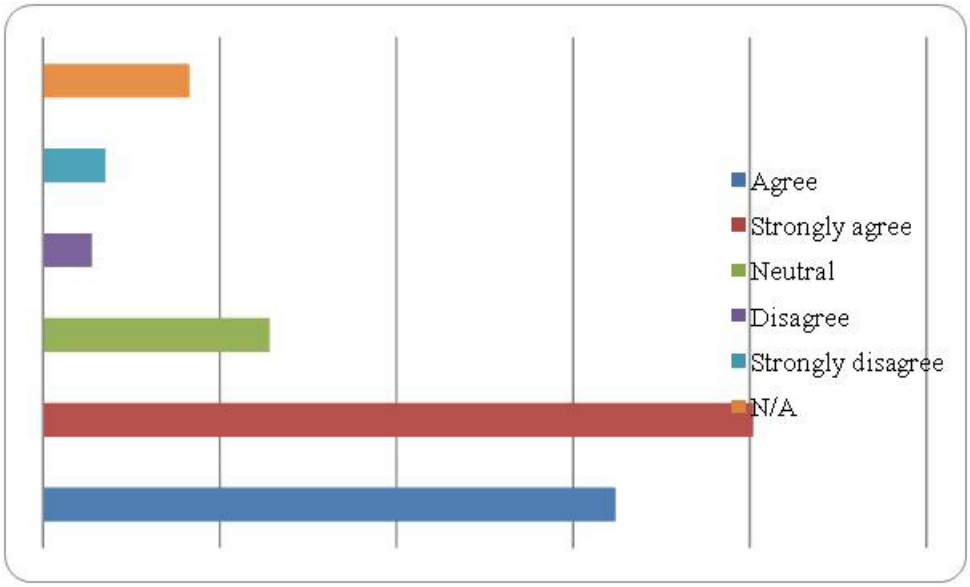

Figure 4. Whether climate change poses risk to individual farmers
***Source*:** Field survey data, 2018

Table 3. Impact of climate change on crop production

Effect on crop production	Frequency	Percent
Declined due to drought	161	26.70
Decrease in crop production due to floods	99	16.26
Decreased due to lack of knowledge of the use of new methods of farming	90	15.78
High since local seeds are resistant to drought and pest	24	1.70
Decreased due to emergence crop diseases and pests	46	5.58

***Source*:** Field survey data, 2018

during prolonged drought. The spatial distribution and availability of pasture and water are highly dependent on the pattern and availability of rainfall (Aklilu *et al*., 2013). However, some 11.06% of the respondents reported that livestock production had increased due to good pasture and water while 2.78% were not aware of any effect of climate change on livestock. This is a perception that could be as a result that the study was partly carried out during rainy season. The results are shown in Table 4.

Impact of climate change on income generation

It was observed that most of the households depend on rain-fed agricultural activities for their incomes. This makes these activities to be more vulnerable to drought and flood. These activities are climate dependent implying that income generation will be greatly affected during extreme climatic conditions. 56.87% of the respondents reported that incomes had decreased due to low crop and animal production. 6.04% of the households indicated that incomes had decreased due to price fluctuation in marketing of agricultural products while 3.57% reported that incomes had decreased due to poor weather conditions that hinder business. Most of such households were observed to be engaged in small-scale trade of agricultural produce such as maize grains, vegetables and fruits. 4.67% reported that the incomes had gone down due to poor performance of crops and livestock resulting from lack of capital to purchase the necessary inputs to improve production. However, 17.03% of the farmers reported that incomes had increased due to increase in agricultural production. These were found to be households mostly from high potential areas of the county which included some parts of Rachuonyo south and Ndhiwa sub-counties. The respondents also reported that fish that used to be a major source of incomes mostly for households along Lake Victoria had reduced in numbers forcing them to look for alternative sources of income such as small scale business activities. The reduction in fish catch could be as a result of receding water levels due to changing rainfall amounts, poor farming methods resulting in pollution of water bodies and poor fishing methods. The results are presented in Table 5.

Impact of climate change on settlement patterns

The farmers were asked to respond to whether climate change had any impact on their settlement patterns. 45.73% of the household heads reported that the settlements were being disrupted during drought as some community members were being forced to move with their livestock to look for pasture and water along the rivers and near the lake. 34.67% indicated that they were being displaced almost yearly by floods with those having mud walled houses being most affected as their houses get swept away. This has forced many community members to settle in higher areas to avoid floods leading to high population density in such areas. It is however noted that this increase in population density usually come with constant conflicts over the use of resources such as grazing land and water which are diminishing due to changing climatic conditions. 17.59% reported that there were nucleated settlements along the lake since some households depend on fishing as a source of livelihood while 2.01% of the household heads did not know if climate change was impacting on settlement patterns. The results of the study are presented in Table 6.

Impact of climate change on disease prevalence

The household survey in the study area revealed that prevalence of diseases for crops, animals and human beings had increased in the past ten years. The frequently mentioned human diseases were malaria, respiratory infections, cholera and other water-borne diseases such as amoebic dysentery.32.16% of the respondents indicated the disease prevalence had increased due to drought while 43.73% reported that there was increase in disease prevalence due to floods. 21.61% reported that there was introduction of new diseases for both crops and animals. These diseases could be as a result of change of habitats caused by changing climate. The results of the study are presented in Table 7.

Climate change has created new habitats for disease vectors, resulting in increased prevalence of infectious diseases. According to Sonne, et al., 2017, climate change provides suitable conditions for diverse infectious diseases transmitted through water, air and food. Most disease carriers such as vector organisms, reservoir species of non-human agents and pathogens have particular sensitivity to weather patterns (McMichael et al., 2006). Climate change either directly affects the life cycle, survival and reproduction of pathogens or indirectly influence their activities by manipulating the local conditions like environments and other competitors for the pathogens (Guerra, et al., 2008). A rise in temperature can influence the reproduction and extrinsic incubation period (EIP) of pathogens. For example the EIP of Plasmodium falciparum reduces from 26 days at 20°C to 13 days at 25°C (Harvell, et al., 2002; Bunyavanich, et al., 2003). This highlights the rate at which malaria causing pathogen can respond to changing climatic conditions of an area. The infectious diseases transmitted through insects like dengue, cholera and malaria are extremely responsive to climate change (Tian et al., 2015; Kuhn et al., 2005). These diseases could lower the productivity of labour for farm operations resulting in reduced crop and animal production. The

Table 4. Effects of climate change on livestock production

Effects on livestock production	Frequency	Percent
Decreased due to lack of enough pastures for the cattle	226	56.78
Decreased due to emergence of livestock diseases and parasites	117	29.40
Increased due to good pasture and water for the good production of milk and other products	44	11.06
Don't know	11	2.78

***Source*:** Field survey data, 2018

Table 5. Effect of climate change on income generation

Effects on income generation	Frequency	Percent
Decreased due to fluctuation of prices in the market for the farm products	22	6.04
Decreased due to lack of enough capital for maintenance of both crops and livestock products	51	4.67
Decreased due to low crop and animal production	246	56.87
High due to increased agricultural production	62	17.03
Low due to poor weather that hinder business and others	17	3.57

***Source*:** Field survey data, 2018

Table 6. Effect of climate change on settlement patterns

Effect on settlement patterns	Frequency	Percent
Are disrupted by drought	182	45.73
Displaced because of floods	138	34.67
Nucleated along the lake as most people depend on fishing as a source of livelihood	70	17.59
Don't know	8	2.01

***Source*:** Field survey data, 2018

Table 7. Effects of climate change on disease prevalence

Disease prevalence	Frequency	Percent
High Due to drought	128	32.16
High due to outbreak of cholera, malaria and other water-borne diseases during floods	174	43.72
Increased due to introduction of new diseases to both crops and animals	86	21.61
Don't know	10	2.51

***Source*:** Field survey data, 2018

management of these diseases would also put financial pressure on the resource poor households.

Climate change adaptation strategies by smallholder farmers in the study area

Farmers in the study area reported several adaptation strategies that they practice to reduce the effects of climate change. These included changing of planting date (25.63% of the respondents), planting short season crop varieties (14.82%), and planting drought resistant crop varieties (19.60%), planting trees (32.42%), and water harvesting (6.03%), as presented in Table 8. Other climate change adaptation measures reported by a male key informant interviewee include *"planting of crop varieties tolerant and resistant to both pests and diseases, keeping animals tolerant diseases, parasites such as zebu cattle, crop rotation, soil and water conservation, conservation agriculture and rehabilitation of degraded pastures" (Senior Agricultural Officer, Ministry of agriculture, Homabay County – May, 2018)*. It is observed that tree planting was more preferred adaptation strategy by households in the study area. This could be partly because trees supplement household incomes and probably due to concerted efforts by government and other agencies in the study area encouraging the farmers to plant trees to improve vegetation cover. This was indicated by two male key informant interview participants who said that *"we encourage households and schools to plant trees, particularly indigenous species to improve on the*

Table 8. Climate change adaptation measures

Measures to cope environmental changes	Frequency	Percent
Changing planting date	102	25.63
Planting of short season crops	59	14.82
Planting of drought resistant crop varieties	78	19.60
Planting of trees	129	32.42
Water harvesting	24	6.03
Don't know	6	1.51

***Source*:** Field survey data, 2018

vegetation cover through training and provision of tree seedlings" (Environmental Officer, World Vision, Kwabwayi Division; Project Coordinator, Strengthening Community Resilience (SCORES) Homabay County-May, 2018). Adoption of the strategies to cope with the effects of climate variability and change could be the only cheaper alternative for households to at least escape the effects of climate change and realize increased agricultural production at household level. The respondents reported that planting only start at the commencement of rains which have become more unpredictable and unreliable. This implies that farmers no longer practice dry planting in anticipation of the rains. Rain water harvesting was observed to be not popular with most households even though over 50% of Homabay County is classified as semi-arid. Responding to water scarcity stress and the threat of declines in crop yields require farm level intervention such as rainwater harvesting and establishing small-scale water reservoirs on farmlands (Osman-Elasha, 2010). Water harvesting structures includes a number of topographical measures that are used for collecting rainwater from a surface area (Bernier et al., 2015). Rainwater harvesting schemes have also made more water available closer to communities, meaning less time and energy spent on gathering water from distant and possibly unsafe water sources (Aroka, 2010). According to Malesu et al. (2006), water harvesting in Lare Division, Kenya has improved access to clean water and consequently improved health status of the local community. However, high investment costs and knowledge requirements restrict widespread up-take by smallholder farmers in SSA (Fox et al., 2005). Among those who were involved in water harvesting in the study area, majority were using small containers such as drums, buckets and jerry cans. Very few had water tanks. Other homesteads had grass thatched rooftops which are not suitable for rainwater harvesting.

Tree planting was commonly practiced to supplement household incomes. However, due to limited land, most farmers practiced agroforestry where annual crops are intercropped with woody perennials. Agroforestry provides a means of diversification and enables the farmers to spread risks and environmental benefits. Agroforestry is increasingly recognized as a sustainable land use in multi-functional landscapes which enhances farmers' ability to adapt to climate change because of the multiple benefits it delivers including food provision, supplementary income and environmental services (Lasco et al., 2011; Schoeneberger et al., 2012; Syampungani et al., 2010). Agroforestry may increase productivity and improve quality of air, soil, and water, biodiversity, pests and diseases, and improves nutrient cycling (Jose, 2009; Smith et al., 2012).This however is a resource demanding land use practice that also require that farmers be knowledgeable on how to combine various agroforestry farming systems. This would therefore require that farmers are constantly trained probably through agricultural extension services. Bryan et al. (2013) and Deressa et al. (2009) found that expensive measures such as agroforestry, fertilizer application, irrigation and soil and water conservation methods are often fostered by access to non-farm income, access to credit and extension services and household wealth. Cheaper measures such as changes in planting date and changes in crop variety are influenced by having access to weather information, education and social safety nets (Bryan et al., 2013; Deressa et al., 2009).

CONCLUSION

The study revealed that smallholder farmers had experienced increase in temperature, declining humidity and precipitation and this was affecting agricultural production in Homabay County. Given that most households heavily depend on rain-fed crop farming and livestock production for their livelihoods, they are very vulnerable to adverse weather conditions. The major changes reported and ranked in order of importance during focus group discussions included prolonged dry spells, heavy but occasional rainfalls accompanied by floods, dried water points, diminishing grazing areas, encroachment of human activities into forests, shorter rainy seasons and diminishing indigenous tree species. Climate change has also resulted in creation of new habitats resulting in outbreak of livestock and human diseases. Farmers reported emergence of new crop pest and diseases, including maize fall army worms (*Spodoptera frugiperda*) and Maize Lethal Necrosis (MLN) disease, which had caused reduced yields in maize. The perceptions of climate change by smallholder farmers could be partly determined by the farmers'

farming experience and the length of time stayed in the study area. The farming experience had enhanced indigenous local knowledge of farmers on climate events. Those who had been practising farming for a long time perceived long-term changes in temperature, precipitation and rainfall variability. These changes had influenced adoption of agronomic practices, livestock practices and socio-cultural practices to adapt to climate change and variability.

RECOMMENDATION

In order to improve agricultural production in the study area and ensure food security the study recommends the need to entrench agricultural systems that build resilience to climate change and reduce green-house gas emissions from farming activities. This should involve alternative livelihood systems such as beekeeping, weaving, fish farming and agroforestry with attention given to fruit production to reduce reliance on rain-fed agriculture. There is also need to have reliable and accessible weather information to enhance farmers' mitigation preparedness in curbing climate change impact. The link between the department of agriculture and meteorological department should be strengthened for easy dissemination of weather information. There is need for establishment of meteorological stations at levels that can be accessed by the farmers. These could include community resource centres and schools while community resource persons and teachers are empowered to disseminate climate information to farmers.

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